# Operational X-Band Maser System

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*Laboratory tests on the first operational X-band maser system for Viking have been completed in the laboratory. Over 50-MHz bandwidth has been achieved with 45-dB gain and a noise temperature of 8 kelvins. Implementation at the 64-meter stations is scheduled for the first half of calendar year 1975.*

## I. Introduction

The ground support requirements for the Viking project include low noise reception in the 8400- to 8435-MHz frequency band. The design parameters of the traveling-wave maser amplifier structure were discussed in detail and preliminary test maser results were presented in an earlier report (Ref. 1). The design of the overall maser system has now been completed. The fabrication and test phase is nearing completion with implementation at the 64-meter stations scheduled during the first half of calendar year 1975. This report describes the hardware and test results.

## II. Design Considerations

At the outset of the operational X-band maser program, the desired amplifier performance was established:

(a) Frequency range: 8400 to 8435 MHz

(b) Instantaneous 1-dB bandwidth: 35 MHz minimum

(c) Gain: 45 dB

(d) Noise temperature: 8 kelvins

Other decisions made in the early phase of the program were to use a superconducting magnet for improved gain and phase stability and to base the operational design of the traveling-wave maser structure and the magnets on R&D developments reported earlier (Refs. 2 and 3). The same closed-cycle cryogenic system as that used with the operational Block III S-band maser system was selected. In planning the design philosophy of the instrumentation, it was decided to utilize Block IV receiver modules in the maser monitor equipment wherever practical. This eased the design requirements, simplified station spares and maintenance, and resulted in fabrication economy. The X-band maser instrumentation was planned to be integrated with the Block III S-band maser equipment so as to utilize existing calibration equipment where feasible.

The use of existing packaging designs was stressed to minimize design and documentation costs. Provisions were made for the future addition of a second X-band maser where this could be done without adding significant cost.

## III. X-Band Maser System Equipment

A block diagram of the X-band maser equipment is shown in Figs. 1 and 2. Figure 1 details the portion of the equipment installed within the X-Band Receive Only (XRO) feed cone assembly. Figure 2 details the equipment mounted in module 3 of the tricone, in the alidade compressor room, and in the station control room.

The major units housed in the XRO cone assembly are the Traveling-Wave Maser/Closed-Cycle Refrigerator (TWM/CCR) assembly and the X-band monitor receiver. The TWM/CCR assembly shown in Fig. 3 includes the helium refrigerator, which houses the traveling-wave maser structure with its field spreading coils and the superconducting magnet. The input and output waveguides with cooled low-pass filters for preventing pump leakage are also housed in the refrigerator along with the magnet charging heater and a Mistor[1] bridge circuit for measuring the magnetic field. The interior of the refrigerator is shown in Fig. 4. The TWM/CCR assembly also includes the maser calibration and pump boxes. The maser calibration box permits test signals to be routed into either the maser input or the maser output. The pump box includes two klystrons which are simultaneously combined and injected into the traveling-wave maser structure. The pump box also includes a modulator (Ref. 1) which frequency modulates the two klystrons at a 100-kHz rate.

The X-band monitor receiver elements are shown in Fig. 1. All of the elements shown are identical to Block IV receiver components. A sample of the maser output is coupled into an X-band mixer with the local oscillator (LO) signal supplied through a times 17 frequency multiplier. The intermediate frequency (IF) output is 325 MHz.

As indicated in Fig. 2, the maser output signal is transmitted to the receiver select assembly in module 3 of the tricone where the signal is distributed into four available output channels for the Block IV receiver.

The output of the X-band monitor receiver is transmitted to the IF selector box. Provisions are also made in this box to receive 325-MHz signals from the Block IV receiver. The operator selects one of these signals, which is then transmitted to the 325-MHz IF amplifier and mixer assembly, where it is mixed with a crystal-controlled 270-MHz local oscillator. A dual output is generated: one output at 325 MHz and one at 50 MHz. The 325-MHz output is transmitted to the control cabinet and into a commercial spectrum analyzer on which the passband of the maser is displayed. The 50-MHz signal is routed into S-band control cabinet No. 2, in which it can be selected for the existing Y-factor equipment for calibration purposes. The monitor receiver cabinet in the tricone also includes a times 10 frequency multiplier fed by a 47.6-MHz crystal-controlled oscillator mounted in the control room in the X-band maser control cabinet (cabinet 3). The times 10 frequency multiplier, the 325-MHz IF amplifier and mixer, and the times 6 frequency multiplier are all standard Block IV receiver modules. In addition, cabinet 3 houses the various power supplies, controls, and quartz thermometer readout for operation of the X-band maser. Figure 5 shows the equipment mounted in cabinet 3.

The compressor for operating the helium refrigerator of the X-band maser is housed in the alidade compressor room.

## IV. Results

The first X-band maser system has now been assembled and has been tested in the laboratory. A typical response curve of the maser is shown in Fig. 6. It is noted that a 45-dB gain is achieved with an instantaneous bandwidth of more than 50 MHz. The noise temperature of the maser has been measured at 8 kelvins. A detailed report on the traveling-wave maser structure development is planned in the near future. The laboratory tests of the first operational system indicate that the design goals have been met with some margin to spare. It is anticipated that all three systems will be completed and installed in the 64-meter stations during the first half of calendar year 1975.

[1] Mistor is a trade mark name for a solid-state, thin-film magnetic flux-sensitive resistor.

# References


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2. Clauss, R., Wiebe, E., and Quinn, R., "Low Noise Receivers: Microwave Maser Development," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XI, pp. 71–80, Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1972.

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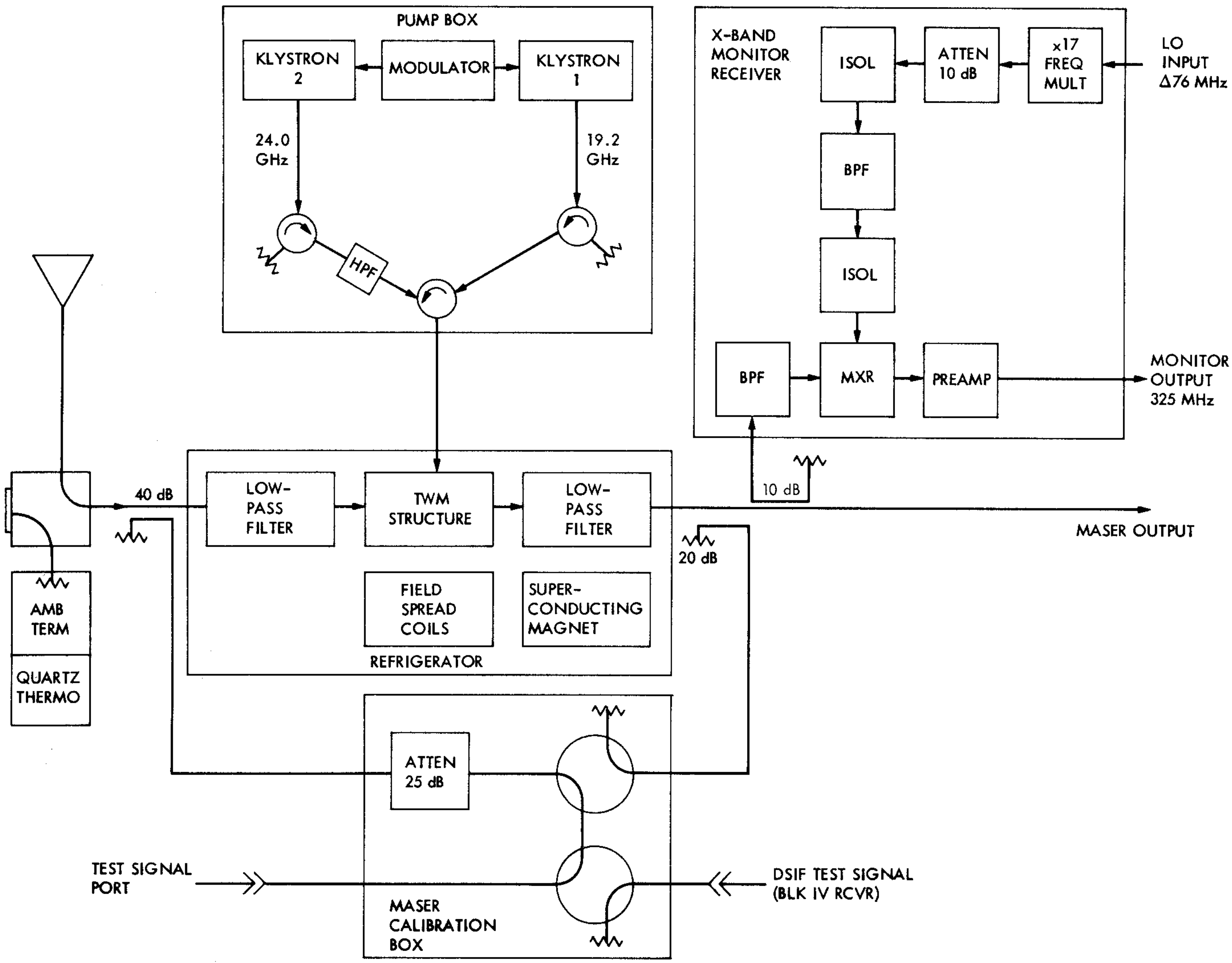


Fig. 1. X-band maser equipment: cone mounted

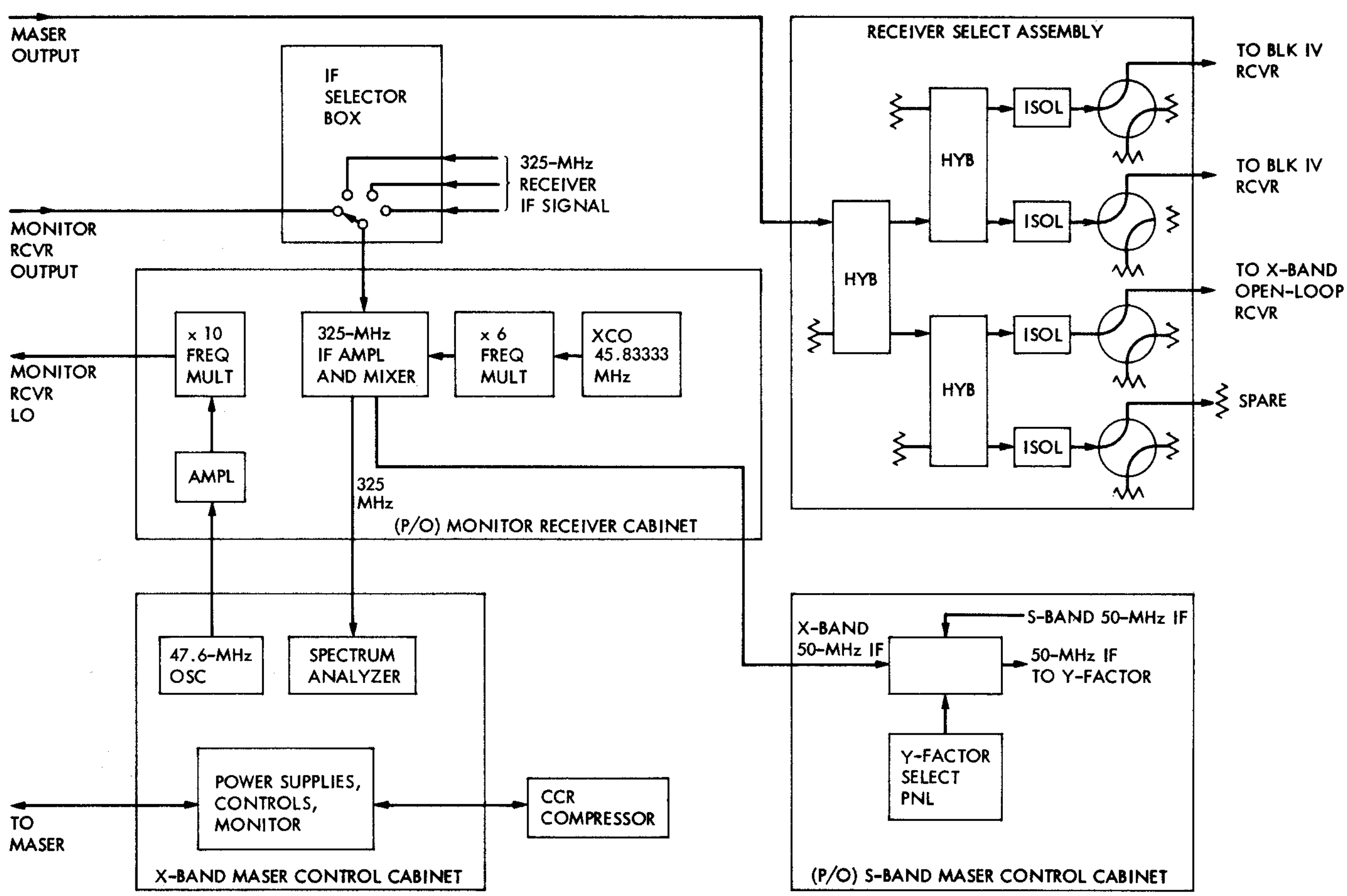


**Fig. 2. X-band maser equipment: tricone, alidade, and control room**

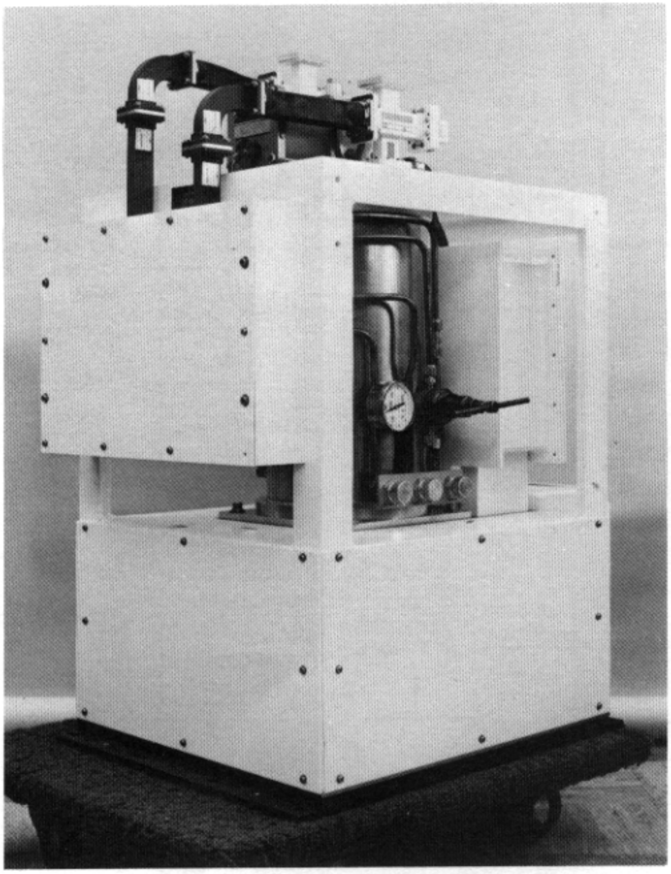

Fig. 3. TWM/CCR assembly

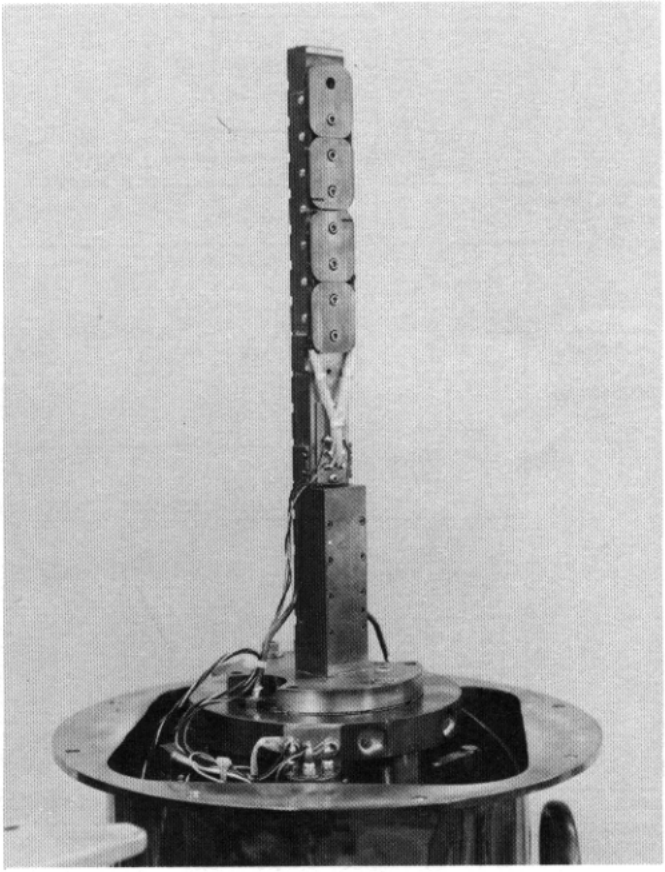

Fig. 4. Interior of refrigerator

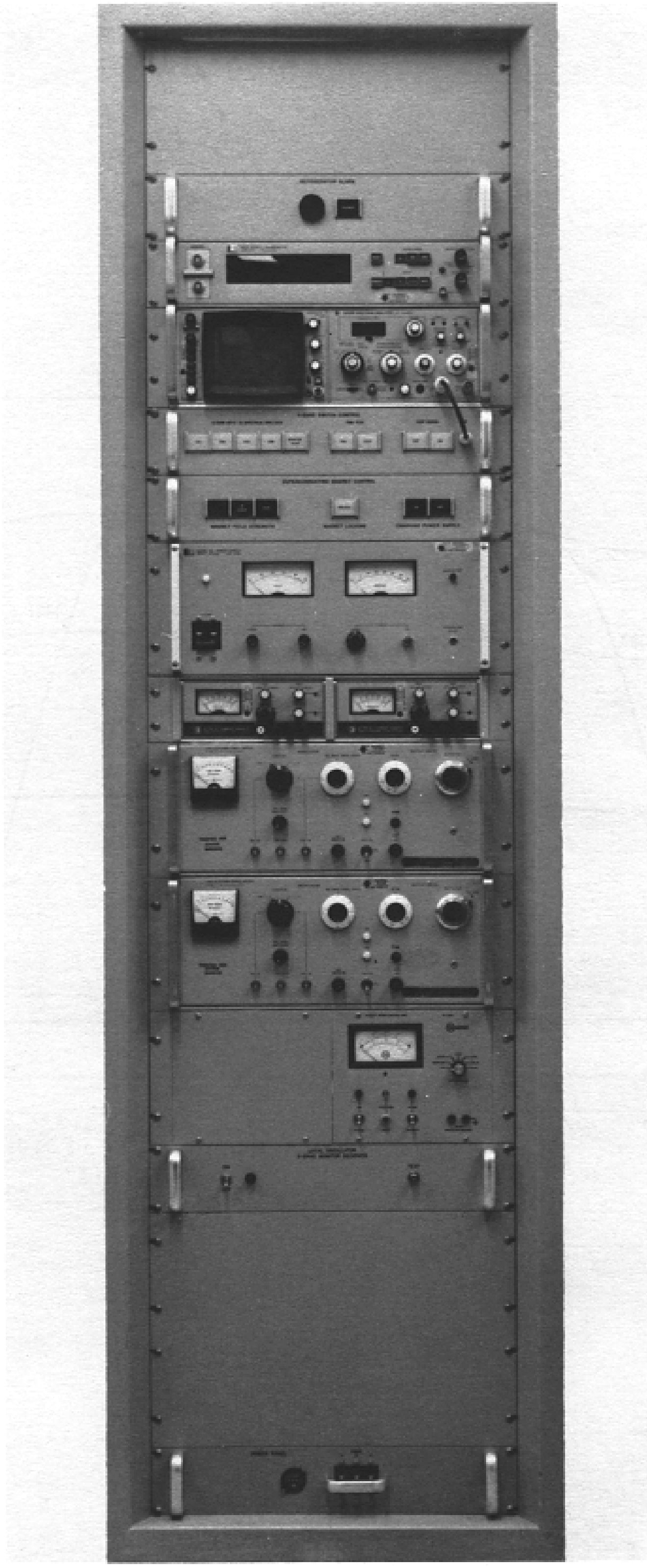

Fig. 5. Cabinet 3 controls and instrumentation

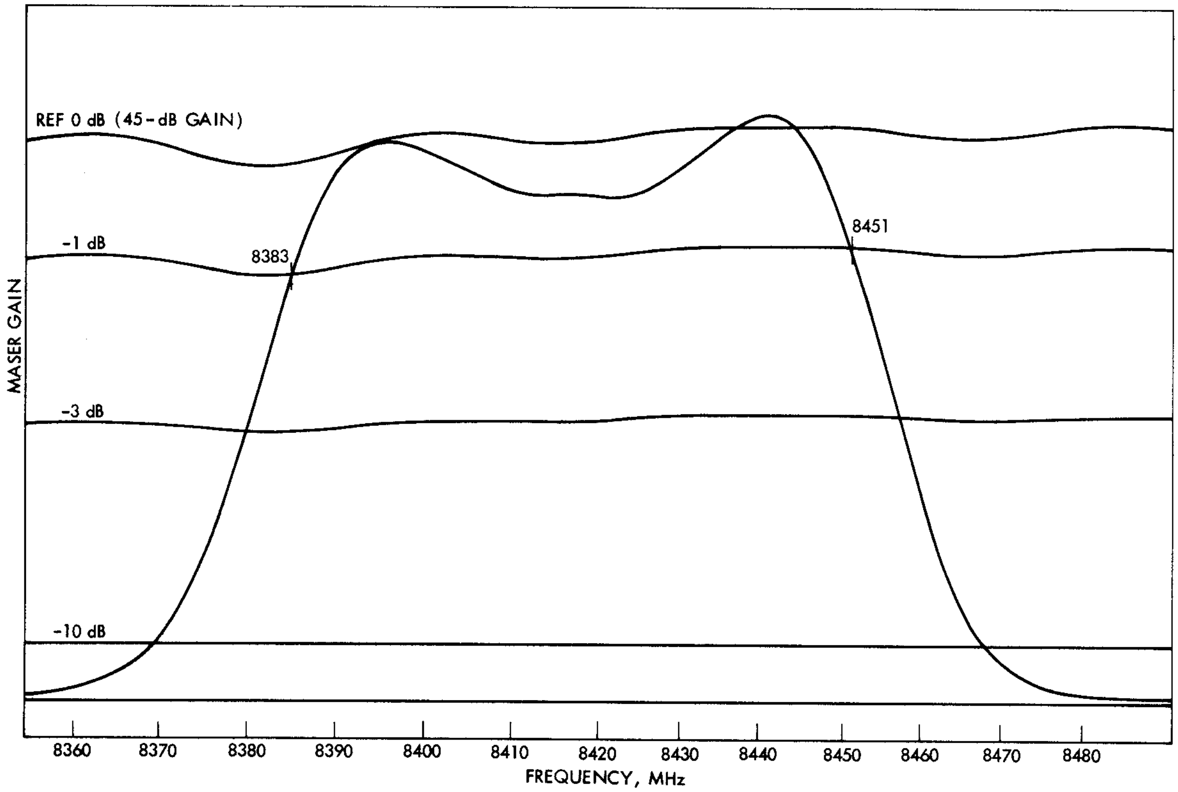


**Fig. 6. X-band maser response**